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Motor Imagery Learning using a Brain-Computer Interface with Auditory Feedback

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It is common to display data visually in most cases as vision is generally accepted as our most important sense. This communication channel is however not available to everyone such as those with sight problems or those in advanced stages motor-neurone disease making them ideal candidates for a brain-computer interface (BCI) which makes use of the auditory channel to relay information to the user. This study aims to assess the potential benefits that auditory feedback affords in the absence of any visual feedback when voluntarily modulating sensorimotor rhythms. Six healthy volunteers with normal vision and hearing took part in 10 sessions. Three were offered visual feedback whilst 3 were given auditory feedback. A training session (**Error! Reference source not found.**) was necessary in order to tune parameters specific to each participant, further details of which can be found in [1][2] where the complete BCI is described in detail.

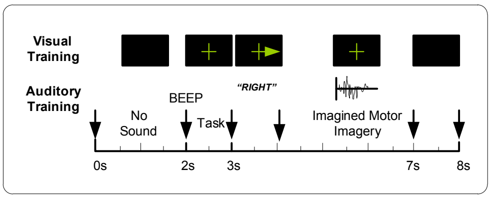

Figure 1: Training Session Timings

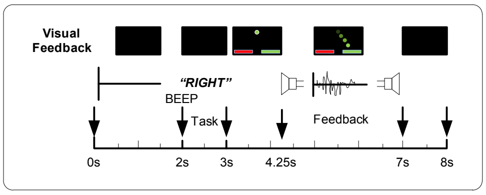

Figure 3: Feedback Session Timings

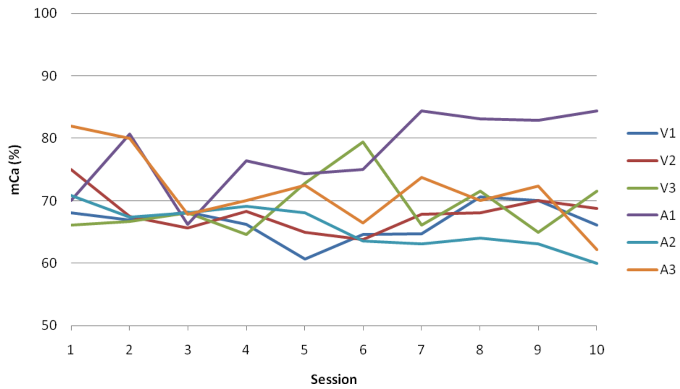

Figure 2: Results for All Participants

On presentation of the task the subject was required to imagine ipsilateral arm movement and received feedback (**Error! Reference source not found.**). The visual task was to direct the ball toward the green basket and this was achieved by voluntary sensorimotor imagery. The auditory group received feedback in order to inform the participant of changes in the azimuth or horizontal positioning of a sound source.

The auditory group performed better overall with an average maximum (peak) mCA (mean classification accuracy) of 71.73% (S.D. ± 2.77) when compared against the visual group at 67.94% (S.D. ± 1.5). Everyone who took part attained 70% accuracy at least once during the study (Figure 2); however, only one auditory subject was able to do this for more than 6 sessions. This study demonstrates the feasibility of the use of auditory feedback as a replacement for its visual equivalent. A follow-up study will make use of a musical 'palette' which will contain various styles of musical feedback. The study continues and will culminate with the completion of 10 visual and 10 auditory participants each taking part in 10 sessions. It is planned to use a modified set of earphones in future studies which will not block the ear canal completely and will allow the participant to not only hear audio from the system, but also to hear sounds from their environment aiding in communication.

References

[1] D. Coyle, "Neural network based auto association and time-series prediction for biosignal processing in brain-computer interfaces," *IEEE Computational Intelligence Magazine*, vol. 4, 2009, p. 47–59.

[2] D. Coyle, J. Garcia, A. Satti, and T. M. McGinnity, "EEG-based Continuous Control of a Game using a 3 Channel Motor Imagery BCI", IEEE Symposium Series on Computational Intelligence, pp. 88-93, April, 2011.